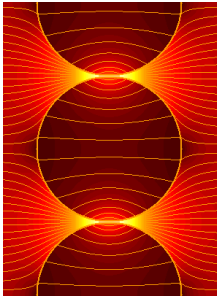


Energy Storage Test Bed Design Issues



David Rosewater and
Benjamin Schenkman

Presentation for

EMA Energy Storage Workshop

Singapore

August 2015

SANDIA REPORT
SAND2014-0482
Energy Storage
Presented November 2012

Evaluating Utility Procured Electric
Energy Storage Resources: A
Perspective for State Electric Utility
Regulators

A Study for the DOE Energy Storage Systems Program
Chris Schaeffer and Mike Lippert

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SAND Number: 2015-6237C

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Energy Storage Test Pad (ESTP)



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The Need for an Energy Storage Test Pad



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- **Evaluate large scale ~ 100KW - 1MW AC electrical energy storage (EES) systems:**
 - Test EES systems for performance to the various storage applications
 - Insure compliance with various standards i.e., IEEE 1547
 - Test for round trip system efficiency, system operation, system performance
- **Test EES systems with renewable energy systems**

Capabilities of Energy Storage Test Pad at Distributed Energy Test Laboratory (DETL)



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- **Enable vendors of large scale battery systems (≤ 1 MW AC) and electrical utilities to obtain a non-bias performance evaluation.**

Prototype and pre-commercial

- **Utility connected EES tests can be performed in a controlled environment**
- **Islanded tests can be performed utilizing DETL's microgrid**
- **Test EES performance to various power and energy applications – time shift, load following, regulation, power quality/reliability**
- **Use of sub-cycle metering for transient analysis**
- **Develop improved energy storage models using gathered field measured data**
- **Enhance control algorithms**

DETL / ESTP Aerial View



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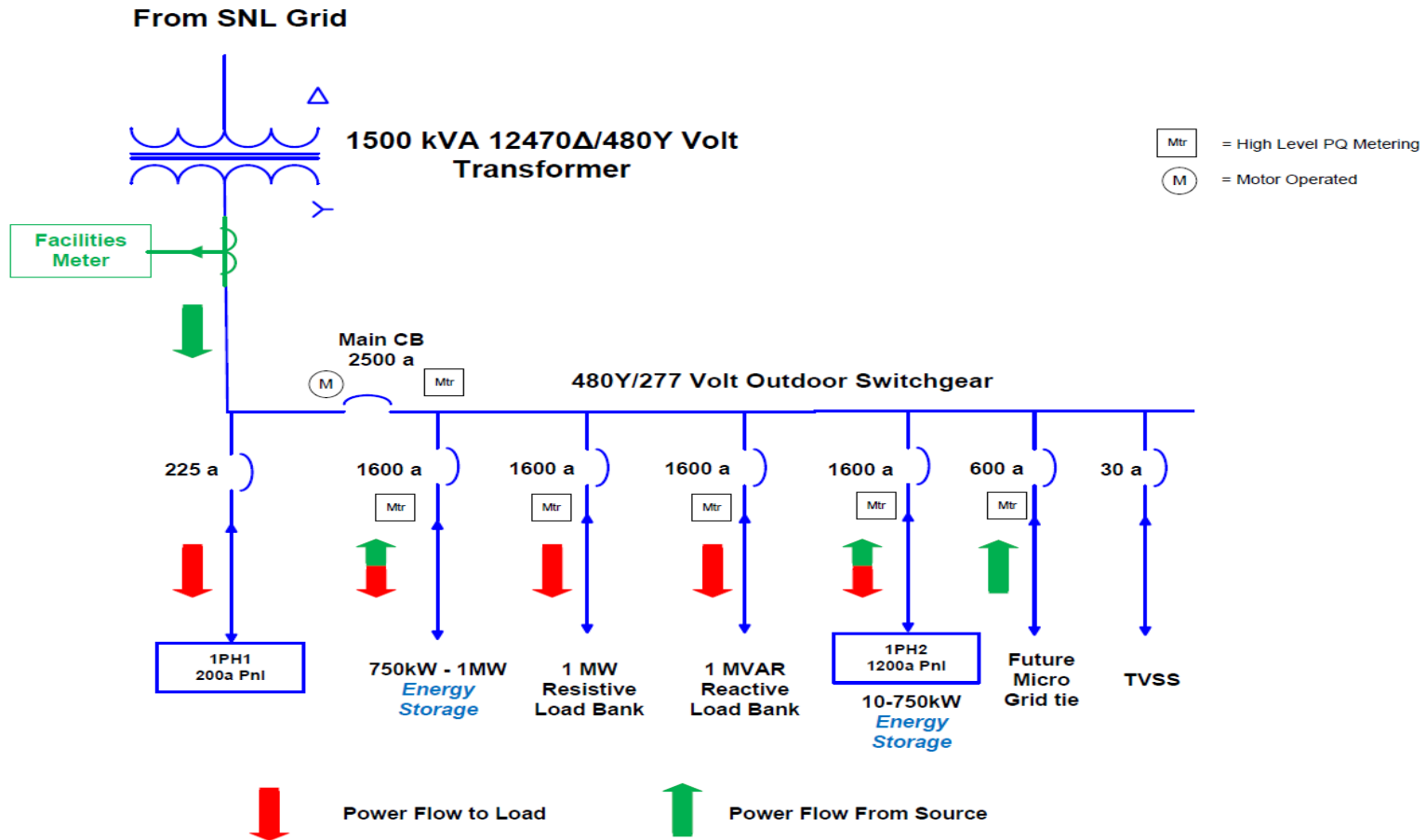
ESTP Single-Line Diagram



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Energy Storage Test Pad Albuquerque, NM



Test Pad Construction



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- **Project status at Phase A:**
 - Phase A – 2500 amp switchgear, 12470/480 3ph transformer, and 1MW/1MVAR load bank purchased and installed.
- **As additional funds become available remaining work will be completed:**
 - Phase B – Complete power wiring and terminations, Complete remote control wiring and soft/ware hardware, complete electrical connection to DETL microgrid.

Safety Considerations



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- Use of existing DETL Technical Work Planning (TWP) and Preliminary Hazard Screening (PHS) as basis of additional documents required for the ESTP
- Initial meeting was set up with ES&H to determine what additional info or documents were required based on Division Work Planning and Control processes
- As each EES system was bought in for testing, individual Job Hazard Screening (JHS) reports were developed by client and Sandia. JHS reports comply with Sandia requirements and include test plan and risk identification and mitigation:
 - Safety considerations
 - Switching procedures
 - Testing requirements
- Utilization of lessons learned process to proliferate learnings throughout industry
 - Testing protocols

Enhancement to SNL's Battery Testing Capability



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- **Initial system performed DC testing at the cell and module level:**
 - Two circuit tester of 1000 amp, 72 VDC (~75kw) per circuit.
 - 2 testers rated at 200 Amp, 60VDC (10KW)
 - 48 channel tester rated at 10 Amp, 10 VDC (100 watts/channel; ability to parallel 5 channels to 500 Watts)
 - 4 channel tester rated at 5 Amp, 5VDC (25 watt/channel)
 - 5 channel tester rated at 25 Amp, 54VDC (1.2KW)
 - 3 channel tester rated at 100 Amp, 54 VDC (5KW)

Enhancement to SNL's Battery Testing Capability (cont.)



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■ **ESTP added capability to test AC systems up to 1 MW, 480 VAC, 3 Phase**

1.5 MVA, 12470 V to 480 V 3 phase transformer

- 2500 amp switchboard with motor operated main breaker
- Five feeder breakers adjustable from 200 amps to 1600 amps
- Test capability up to 1 MW AC electrical energy storage systems:
 - Flow batteries, Li-ion, LA, Flywheels. NaS, and new technologies
- Initial system: Capable of a 1600 amp single point of EES connection or
- Multiple feed connections through a 1200 amp branch panel
- 1 MW resistive load bank
- 1 MVAR reactive load bank
- Future enhancement- allows load banks to be controlled from a PLC to closer match customer loading profile
- Sub-cycle metering on feeder breakers for transient analysis

- **ESTP is located on the DETL site. Initially, ESTP connected to the grid (no connection to DETL microgrid initial configuration).**
 - Allowed evaluation an EES system in grid tied power and energy applications, i.e., freq regulation, ramping, cycling, time shifting.
- **ESTP operation and personnel / staff**
 - One engineer and one part-time technician
 - Sandia supports development of test plans in concert with clients and or Vendors and approves all test plans
 - Sandia supervises all testing activities. Sandia operates its systems; and clients will operate their EES system.
- **Testing coordination**
 - As a stand alone system notification required to DETL and facilities.
 - Coordination required with DETL when tied to the microgrid.

Services Provided



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- **Provide testing of the applications outlined in SAND reports:**
 - Power – Area Regulation, Power Quality, Voltage Support, Load Following, etc.
 - Energy - Energy Time Shift, Supply Capacity
- **Test the efficiency and capability of system**
- **Test to any applicable industry standards**
- **Provide product improvement support and new product development**
- **Demonstrate performance:**
 - Ramp rates, storage operational characteristics, power electronics operational characteristics, R/T efficiency, cycle capability, power quality, charge and discharge capability, component behavior
- **Provide written analysis of EES system performance**

Collaboration Opportunities



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- **Work with EES manufacturers, utilities, R&D entities both public /private, other testing providers and end users.**
 - Work For Other Agreement
 - DOE office of Electricity directives
- **Our challenge as a national lab is to position our services so as not to compete with private testing entities.**
 - Sandia is non-compete entity
- **Potential clients include manufacturers of**
 - Flow batteries, Li-ion, FOA 36 ARRA awardees, Advanced Lead Acid, Flywheels, New electrochemical or electro-mechanical storage systems.

Future Upgrades



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- **Modifications include:**
 - Connection to DETL microgrid - This allows evaluation of EES systems in a microgrid application with 75 KW genset and 130 KW PV array, etc.
 - Remote control of load bank
 - Remote control communications in place to remotely control EES system

Summary



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- **ESTP compliments Sandia's existing DC cell testing capability by providing AC system testing**
- **ESTP is used to evaluate performance and compliance of large scale AC EES systems while interconnected to the electric utility or islanded**
- **Future enhancement of the testing facility include interconnection to the existing 480V AC DETL microgrid and additional user interface automation/control.**

Need More Information?



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